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A Study on Simulation Methods for AGV Fleet Size Estimation in a Flexible Manufacturing System

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Abstract

This paper presents a study on the estimation of fleet size of Automated Guided Vehicle (AGV). Determination of AGV fleet size plays a decisive role on the performance of job shop environment. Simulation methods are studied in detail for the estimation of AGV fleet size in a Flexible Manufacturing System. The presented methods are based on either minimization of total travel time or overall cost. Analytical methods are used for initial estimation of fleet size. Simulation methods give better results but in complex situations, simulation methods are cumbersome.

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Keywords: Automated Guided vehicles; Material Handling; Flexible Manufacturing System; AGV number; Simulation methods.

1. Introduction

The American Society of Safety Engineers (ASSE) defined AGV as:

a. Machines without drivers that can move along pre-programmed routes, or use sensory and navigation devices to find their own way around.
b. Vehicles that are equipped with automatic guidance systems capable of following prescribed paths or driverless vehicles that are programmed to follow guide path.

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AGVs have expertise in completing the assigned job effectively and efficiently in a Flexible Manufacturing System (FMS) [1]. During their early days in industry, their usage was limited after then with rapid increase in the focus of researchers in this region made AGVs as synonyms for automation in production industry. The Automated Guided Vehicle System (AGVS) is computerized control system that manages all the AGVs to coordinate with each other to complete intended tasks, which results in decreased labor and the dangerousness while improving the throughput [2]. Material handling is a key process in manufacturing system as it unifies various manufacturing operations [3]. Unlike the traditional material handling system (MHS), where human element is involved in the transportation of materials between various locations, human intervention is almost non-existent in FMS [4]. The development of AGVS for the transportation of materials in between work stations brings many benefits to a manufacturing system. It helps to control the flow of material so that the right materials arrive at the right place at the right time. Hence, to stay competitive, the usage of automated guided vehicles (AGV) should become a part and parcel in production environment [5]. There are several operational issues that should be studied carefully in order to make AGVS to function effectively. Vehicle number in an AGVS affects performance of the system. Increase in overall cost and overcrowding are the effects of overestimation of vehicle number whereas underestimation of vehicle number cannot promise the fulfillment of task assignment. Factors affecting the number of vehicles are: system layout, location of load transfer points, trip exchanges between work centers per unit time, vehicle dispatching strategy, system reliability, and speed of travel [6]. Determination of optimum number of vehicles becomes complicated under detailed time phased pickup/drop off location, pickup/drop off floor area capacity, dispatching rules [7]. Minimizing the number of vehicles depends on the operational vehicle dispatching rules for a known material, known volume and system layout configuration. To determine the optimum number of vehicles, analytical and simulation methods are mostly used [8]. The reliable estimation of number of vehicles required in a job shop environment is obtained by simulation. Simulation is a time taking process. So, the fleet size of AGV is estimated with some rough calculation (analytical methods) in order to carry economic analysis [6]. In this paper the authors focuses on the simulation studies on fleet size of AGV. Section 2 provides an out view of analytical methods proposed in the literature and section 3 discusses about simulation studies for vehicle number estimation. Conclusions of this study are presented in Section 4.

2. Analytical models for fleet size estimation

Many analytical models for determining number of AGV's have appeared in the literature. Maxwell and Muckstadt [7] proposed a method to determine AGV number which is the ratio of total vehicle time required during the shift and time available on vehicle per shift by measuring empty travel time. Total vehicle time required during shift is sum of loading, unloading, running and empty travel time of all vehicles. Egbelu [6] proposed four analytical methods considering different constraints for different methods. Empty travel time determination is essential to find AGV fleet size so different authors assumed empty travel time in different ways. In Beisteiner [9] first method they assumed empty travel time as a product of total net flow at one station and average loaded vehicle trip time. In Beisteiner second method, total empty travel time is taken equal to total vehicle travel time. Kuhn [10] instead of net flows he considered total number of loads delivered at a station as the number of empty vehicle trips starting from that station. These empty vehicle trips were then routed to various other stations in proportion to the total number of load pickups from those stations. Malmborg [11] maximized empty vehicle travel time instead of minimizing done by Maxwell. Here number of empty trips is based on total number of loads picked up or delivered at a station. Koff [12] considered vehicle idle time as 25% of total vehicle loaded travel time. Vehicle idle time equals to empty travel time and idle wait of a vehicle. Kulweic [13, 14] vehicle empty, idle and block time factors are 0.2, 0.4 and 0.15 respectively. Rajotia [15] minimized total empty travel time under three constraints: The total number of delivered trips at *ith* station is proportional to number of empty travel trips. Number of trips in which delivered vehicle picks up load at the same station i.e, total number of empty travel trips is zero. They compared this model with above methods. Muller [16] and Dahlstrom and Maskin [17] made a comparison of operating cost between different material handling systems based on flow intensity and distance. Sinnriech and Tanchoco [18] determined AGV fleet size on a combined measure of cost and throughput performance.